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Cambridge Walk-Off Mat Study Report

1. INTRODUCTION

This study sought to evaluate the effectiveness of walk-off mats as an aid in controlling lead hazards in an urban setting that has lead-contaminated soil and exterior dust. Previous investigations by Lead-Safe Cambridge (LSC) had found significant soil lead hazards throughout the areas targeted for lead hazard control under funding from HUD. Because treating the soil directly is prohibitively expensive, less expensive ways to reduce the hazard of tracked-in dust need to be found. LSC studied the use of walk-off mats as a supplemental activity with their planned interventions.

The primary objective of this study was to determine whether walk-off mats which are provided to tenants after lead hazard control treatment reduce the amount of lead dust within the home. The study began in March 1998 and continued until December 31, 2000. Two phases of sample collection results are discussed in this report: Phase 2 samples, generally collected within 30 days following intervention; and Phase 3 samples, collected approximately 12 months post-intervention.

2. STUDY METHODOLOGY

The National Center for Lead-Safe Housing (the Center) and LSC worked together to design the protocols for this study and develop the data collection forms (see Appendix A). Units were identified for participation in the HUD Round IV Grant program on a rolling admissions basis and were recruited into the LSC program for subsequent intervention. Using a randomization procedure recommended by the Center, two-thirds of the enrolled units were to be assigned to a "program mat" treatment group, and the remaining one-third to a control ("no mat") group. The ratio of "mat" to "no mat" units was high because researchers expected that many units would already have tenant mats present inside or outside the main entryways. After intervention and clearance testing were complete, all dwellings were visited for mat installation (in "program mat" units) and dust sample collection. Dust sample collection was repeated approximately one year after the first set of samples had been collected. Details concerning the program are provided below.

2.1 Pre-Intervention Data Collection

Prior to intervention, LSC staff used Form 01, Baseline Building Information, to collect basic building and unit information (e.g., building type, age, number of occupants, number of rooms, etc.). LSC staff also used Form 04, Interview-Pre-Intervention, to collect information on factors potentially influencing dust lead levels inside the home. The original study design included a building survey report (Form 02), which was later deleted from the study. Soil sampling was also part of the original study plan (Form 06) but later dropped due to problems with data collection and recordkeeping. Pre-intervention (Phase 1) samples and clearance samples were also to be collected at each unit with results recorded on Form 03, page 1; however, due to problems with collection and recordkeeping for these samples, their results could not be used in this study and are not further discussed.

2.2 Phase 02 Data Collection

Dwellings that underwent lead hazard control were then randomly assigned to the two study groups, those receiving a walk-off mat and those not receiving a walk-off mat. After the completion of clearance testing, a certified lead risk assessor from Housing Environmental Services (HES) visited each dwelling to place a mat just inside the doorway to the unit (if the unit was randomly selected as a "mat unit), and then to collect floor dust wipe samples. Floor samples were collected from the following locations, with relevant information recorded on Form 03, page 2:

- Just outside the primary entrance door to the unit (commonly the hallway);
- Just inside the primary entrance door to the unit. If a program mat was placed in this location, the contractor collected a wipe sample from the newly placed mat;
- 5 feet inside the room, in the direction tenants were routinely expected to walk when entering the unit; and
- on the opposite side of the room.

During this same visit, the HES contractor also conducted a visual inspection to assess the interior condition of each unit at Phase 02 (Form 05).

2.3 Phase 03 Data Collection

During the Phase 03 visit, occurring approximately one year after the Phase 02 visit, the HES contractor collected dust wipe samples from the same four locations that were sampled in Phase 02 (Form 03, page 2). The HES contractor also conducted an interview with any tenants present during the Phase 03 visit, to identify factors that may have influenced Phase 03 dust wipe results (Form 07). Form 07 was also used to record whether a unit was a "mat" unit, whether mat(s) were still present, mat location, and type of mat (i.e., tenant or program). This information along with mat information provided on Form 03, page 2, was used to determine into which study category each unit fit.

2.4 Laboratory Analysis and Quality Assurance/Quality Control (QA/QC)

Wipe samples were sent to METS Labs, an EPA National Lead Laboratory Accreditation Program (NLLAP)-recognized laboratory, for analysis. The laboratory has shown evidence of its proficiency in dust lead analysis under the Environmental Lead Proficiency Analytical Testing Program (ELPAT). All wipe samples were analyzed for total lead according to EPA SW-846, with a method detection limit of 5 µg/sample. QC spikes were to be inserted into the sampling stream at a rate of one spike for every 12 dwellings sampled in both Phases 02 and 03. One blank sample was to be submitted for each day of sampling. QC spike and blank results are provided in Appendix B.

2.5 Recordkeeping and Data Analysis

LSC was responsible for auditing all data for correctness, completeness, and adherence to the data collection protocols. After forms were completed in the field, they were submitted to LSC for initial review by LSC staff for logic and completeness. Forms were then forwarded to the Center. The Center performed a second check of the handwritten forms for missing, unclear or erroneous data, including the use of proper identification codes, proper answer

codes and values, insertion of correct laboratory results and calculations of dust lead loadings. When errors or missing information were found, the Center e-mailed a summary of the errors to LSC, who then made revisions to the handwritten forms and mailed copies of corrected forms to the Center. The Center then performed a final audit before beginning data entry. A Center data entry specialist entered all data (single entry) from the field forms directly into the electronic version of the forms in Jetform's FormFlow software program. The Center then compared each handwritten form with the electronic version to ensure the data were entered correctly and completely.

Statistical analyses of all data were performed using a SAS (Version 8), a statistical analysis program from the SAS Institute.

2.6 Assignment of Study Categories

At the start of the study, it was estimated that two-thirds (approximately 60) of the units enrolled in the program would be assigned to the "program mat" group and the remaining one-third (approximately 36) to the no-mat group. The ratio of "mat" to "no mat" units was high because researchers expected that many units would already have tenant mats present inside or outside the main entryways. In fact, 42% (27) of the units had a tenant mat present when the HES contractor visited the unit at Phase 02. Such units were assigned to the "mat" group, yielding a high ratio of mat to control units. When units were re-visited at one-year post-intervention, several units had either gained or lost program and/or tenant mats. These factors greatly complicated the categorization of units into study categories, leading to the category assignment strategy detailed below. In assigning units to these categories, the presence of a mat was generally determined from information provided on Form 03, page 2. The location of a mat inside or outside the doorway was not considered when assigning units to a particular category. Categories are as follows:

- "No Mat:" Units were assigned to this category if "no mat" was present at either phase. If, in these units, a carpet was dust sampled either inside or outside the door at either Phase 02 or 03, it was thought that this could be a mat that was not appropriately recorded; therefore, to ensure certainty in the "no mat" category, such units were excluded from data analysis.
- "Tenant Mat:" Units were assigned to this category if Question 6b on Form 05 ("Was tenant mat present at phase 02?") was answered "yes" and if there was a mat present at both Phase 02 and Phase 03 based on Form 03. In some units, these tenant mats were removed by the HES contractor at Phase 02 and replaced with program mats. Although the program mats were the mats sampled at Phases 02 and 03 in such units, these units remained in the "tenant mat" category since the presence of the tenant mat prior to the Phase 02 visit could have influenced dust lead loadings inside the home.
- "Program Mat:" Units were assigned to this category if they were not in the "tenant mat" group and if there was a mat present at both phases. In addition, one bare floor and one carpeted floor must have been sampled at Phase 02 (from inside and outside door) for the unit to be assigned to this category. Note that, between Phases 02 and 03, the mat could move between inside and outside the door and still be assigned to this category. Units that had carpeted floor samples collected both inside and outside the door were excluded because carpeted floors have lower dust lead loadings as measured by wipe sampling.

- "Lose Mat:" Units were assigned to this category if they were not in either the "tenant mat" or the "program mat" group, and there was a mat at Phase 02, but not at Phase 03.
- "Gain Mat:" Units were assigned to this category if they were not in either the "tenant mat" or the "program mat" group, and there was a mat at Phase 03, but not at Phase 02.

3. RESULTS

3.1 Identification of Study Datasets

It was originally estimated that 96 units would be identified for participation in the HUD Round IV Grant program on a rolling admissions basis; however, a total of 108 Round IV units were actually completed through clearance. Of these 108 units, only 68 could be included in the study because Round IV enrollment began while study protocols were still in development. Of these 68 units, two units were eliminated from the study because the HES contractor could not gain access to conduct Phase 03 sampling, and one unit was eliminated because of erroneous data that could not be corrected. The resulting dataset of 65 units yielded useful data for evaluating aspects of LSC's program (see Section 3.2).

Several problems arose, however, when the Center tried to use the 65-unit dataset to study the impact of mats on dust lead loadings in the units. Comparison groups were not easy to define due to several factors, including the presence of tenant mats at Phase 02, the removal of program mats between phases, and the addition and removal of tenant mats between phases. (These factors resulted in mat-related data in this large dataset that were complex and difficult to interpret accurately.) A further complication involved certain "no mat" units that had carpets present at one of the doorway sampling locations. Carpeted floors were expected to have an effect on dust lead loadings inside the home similar to that of mats, i.e., carpeted floors may "trap" dust, yielding lower dust lead loadings inside units; therefore, these "no mat" units with carpets could not be included in the mat study.

The Center decided to identify a simpler dataset to be used specifically when evaluating the mats. In order to be included in the mat study dataset, units were required to have only bare floors sampled at the three inside-unit locations (i.e., inside door, 5 feet inside unit, and opposite side of room). In addition, units in the "program mat," "tenant mat," and "gain mat" categories would be included in the mat study dataset only if there was a carpeted floor sampled at the outside door location. These additional restrictions were based on the observation that program mats were routinely placed at the outside door sample location rather than at the inside door location. The final mat study dataset was comprised of 23 units: six "no mat" units, seven "program mat" units, six "tenant mat" units, and four "gain mat" units. The "lose mat" category is not further discussed since only two units fell in this category. Results for this dataset are discussed in Section 3.3.

3.2 Description of Physical Characteristics and Condition of Enrolled Units at Phases 02 and 03

This section uses the larger dataset of 65 units to describe the physical characteristics of enrolled buildings, as well as the condition of enrolled units when the HES contractor visited at Phases 2 and 3. Dust lead loading results for Phases 02 and 03 are included in the discussion.

3.2.1 Building Characteristics

The vast majority (63 units or 98%) of the study units were from buildings constructed prior to 1910, with 83% (54) being rental units. Fifty of the 65 study units (77%) were from multifamily housing having four or more units per building. Other types of multifamily housing represented in the study were triple deckers (9 units), duplex (1 unit) and double deckers (4 units). Only one unit, a rowhouse, was a single family dwelling. Buildings had exteriors made of vinyl/aluminum siding (25 units), brick (16 units), wooden clapboard/shingles (15 units), asphalt/asbestos shingles (8 units), or stucco (1 unit).

Fifty-one of the 65 enrolled units were occupied prior to intervention; however, occupants generally did not include children under the age of six. Prior to intervention, 14 of the 65 units (22%) were unoccupied. The percentage of units remaining unoccupied for the duration of the study is not known.

3.2.2 Condition of Enrolled Units at Phase 02

Visual Inspection. When the HES contractor visited the unit after intervention to collect the Phase 2 samples and place mats in "program mat" units, he also conducted a basic visual inspection of the unit. Nine of the 65 enrolled units (14%) reportedly had deteriorated walls, ceilings, doors and/or trim remaining after intervention; 36 units (55%) had deteriorated floors/carpeting. Four units reportedly had an obvious need for repair of water damage due to heating/cooling or plumbing problems. These results were somewhat surprising considering that units had already undergone lead hazard control; however, the HES contractor noted that while abatement work was limited to lead-painted surfaces, the brief Phase 2 visual assessment covered all painted surfaces, including that not containing lead-based paint. Therefore, deteriorations noted during this visit may have been on surfaces not containing lead-based paint.

Phase 02 Dust Lead Loadings. In addition to the deterioration found during the Phase 02 visual inspection, Phase 02 dust lead loadings were disturbingly high. Phase 02 samples were generally collected within 30 days of treatment completion; however, some Phase 02 visits occurred later, with a maximum of 203 days between intervention and the Phase 02 visit at one unit.[1] Even so, Phase 02 results for all units were expected to be below or near the then-clearance standard of 100 $\mu g/ft^2$. As shown in Table 1, however, high Phase 02 dust lead loadings were found in each sampling location. One-third to one-half (39% to 50%) of units had bare floor dust lead loadings that exceeded a clearance standard of 100 $\mu g/ft^2$. These numbers were even higher when data were compared with the new HUD clearance standard of 40 $\mu g/ft^2$ (effective September 2000): 55% to 87% of units would have failed the lower clearance standard. Maximum Phase 02 dust lead loadings at each sample location were extremely high, varying from 806 $\mu g/ft^2$ to 6,707 $\mu g/ft^2$ on bare floors, and from 264 to 432 $\mu g/ft^2$ on carpeted floors.

As explained by the HES contractor, these high Phase 2 results may be due in part to the large number of multifamily buildings treated in this study and the construction process for units in such buildings. The lead construction contractor worked in only one unit at a time. The HES contractor collected the Phase 2 samples when work in each unit was completed. At the time

[1] Information concerning the time between intervention and the Phase 02 visit is available for only 44 of the 65 study units.

that Phase 2 samples were collected, work in the unit being sampled was complete, but abatement was still being performed in other units in the building, and in many cases, intervention and/or final cleaning had not been performed in the front common halls. Construction contractors performed work in the front common hall and on the building exterior only after work in all units was completed. Also, in at least some buildings, work in the front common halls was minimal, e.g., repair of damaged paint on the ceiling. Many of the highest results were collected from the outside door sample location labeled as "front porch;" track-in at this location may have been an important source of lead dust.

Table 1: Comparison of Phase 02 Dust Lead Loadings with Clearance Standards

	Bare Floors			Carpeted Floors		
	Outside Door (30 units)	Inside Door (32 units)	Inside Room[a] (51 units)	Outside Door (35 units)	Inside Door (33 units)	Inside Room[a] (20 units)
Number & Percent of Units with dust lead >100 µg/ft²	15 (50%)	15 (47%)	20 (39%)	3 (9%)	1 (3%)	2 (10%)
Number and Percent of Units with dust lead >40 µg/ft²	26 (87%)	26 (81%)	28 (55%)	6 (17%)	8 (24%)	5 (25%)
Max. dust lead loading (µg/ft²)	3,712	6,707	806	432	324	264

[a]Statistical testing showed that geometric means for samples collected 5 ft. inside room were not significantly different from those collected from opposite side of room; therefore, data for these two sampling locations were combined prior to preparing data in this table. Since some units had a mixture of carpets and bare floors at these sampling locations, the total number of units for the "inside room" location adds to more than 65.

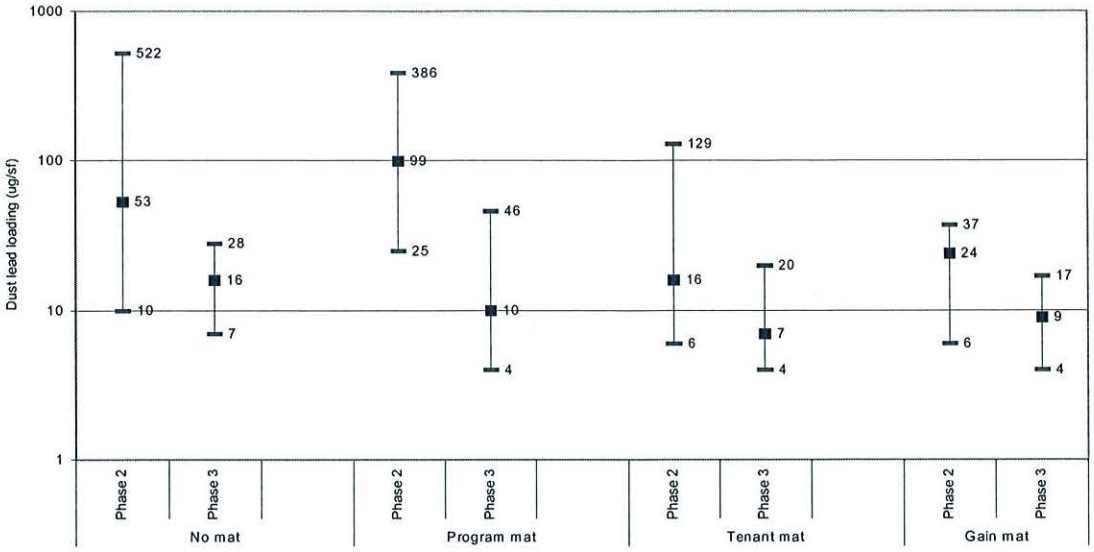
3.2.3 Condition of Enrolled Units at Phase 03

A visual inspection was not done at Phase 03; therefore, this discussion focuses on dust lead loading results for samples collected approximately 12 months after the Phase 02 sampling visit. On the average, Phase 03 visits occurred 12.5 months after the Phase 02 visit, with a minimum of 11 months and a maximum of 17 months between the two visits. All wipe samples were collected from the same locations that were sampled at Phase 02.

Phase 03 Dust Lead Loadings. Phase 03 bare floor and carpeted floor dust lead loading results are summarized in Figures 1 and 2, respectively, and compared with clearance standards in Table 3.

Bare Floors. As shown in Figure 1, Phase 03 bare floor dust lead loadings were far below Phase 02 loadings for samples collected at the same location. Maximum bare floor dust lead loadings, however, remained high (820, 92.3, and 434 µg/ft² at outside door, inside door, and inside room locations, respectively). Many fewer units had bare floor results that exceeded clearance at Phase 03 than at Phase 02 (Table 2); however, four units had outside door concentrations exceeding 100 µg/ft², and two units had inside room results exceeding this standard. Twelve to 44% of units had bare floor results exceeding the new HUD standard of 40 µg/ft². The low Phase 3 results relative to Phase 2 results may be related to the multifamily building construction process described in Section 3.2.2—in many cases, final cleaning in the front common halls likely occurred after the Phase 2 but before the Phase 3 sampling.

Figure 1: Bare Floor Dust Lead Loadings for Phases 02 and 03



Note: Upper bar=95% upper confidence limit; box=geometric mean; lower bar=lower 95% confidence limit
Source: Form 03, page 2, phases 02 and 03.

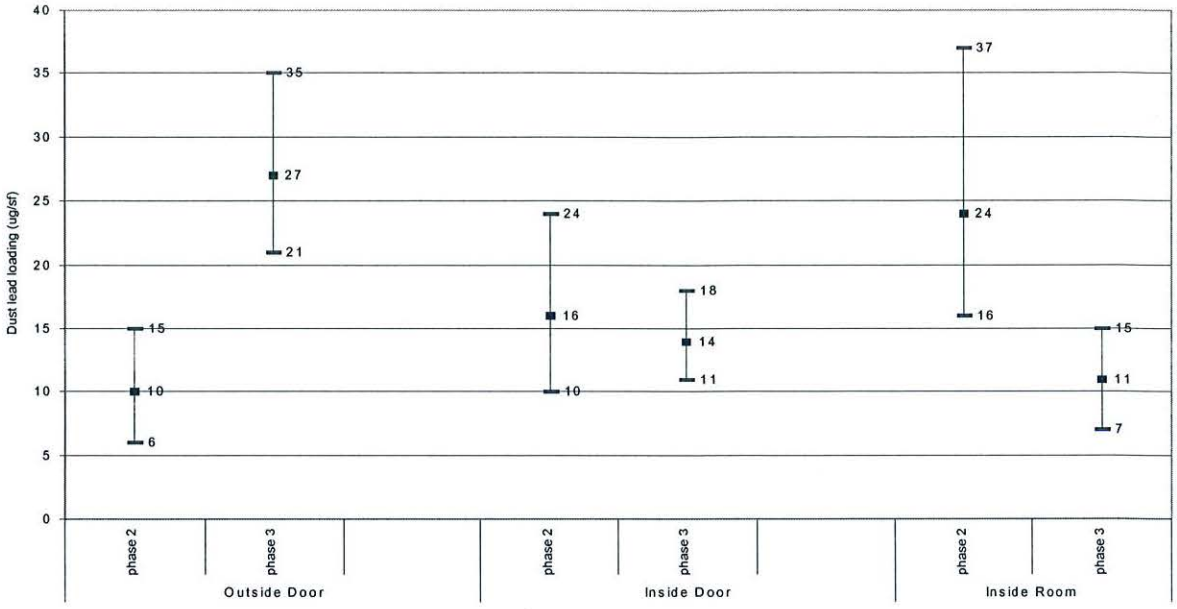
Table 2: Comparison of Phase 03 Dust Lead Loadings with Clearance Standards

	Bare Floors			Carpeted Floors		
	Outside Door (30 units)	**Inside Door (32 units)**	**Inside Room[a] (51 units)**	**Outside Door (35 units)**	**Inside Door (33 units)**	**Inside Room[a] (20 units)**
Number and Percent of Units with dust lead >100 µg/ft²	4 (22%)	0	2 (4%)	2 (4%)	0	3 (13%)
Number and Percent of Units with dust lead >40 µg/ft²	8 (44%)	6 (16%)	6 (12%)	12 (26%)	1 (4%)	3 (13%)
Max. dust lead loading (µg/ft²)	820	92.3	434	339	43.4	183

[a]Statistical testing showed that geometric means for samples collected 5 ft. inside room were not significantly different from those collected from opposite side of room; therefore, data for these two sampling locations were combined prior to preparing data in this table. Since some units had a mixture of carpets and bare floors at these sampling locations, the total number of units for the "inside room" location adds to more than 65.

Carpeted Floors. Not surprisingly, carpeted floor dust lead loadings outside the door tended to increase between phases, presumably because the carpet (e.g., mat) became dirtier over time (Figure 2). Two units had outside door results that exceeded at clearance standard of 100 µg/ft², while three had inside room results above this same standard. Maximum dust lead loadings at these two locations were 339 and 183 µg/ft², respectively, indicating that potential track-in remains a concern one year after intervention.

Figure 2: Carpeted Floor Dust Lead Loadings for Phases 02 and 03



Note: Upper bar=95% upper confidence limit; box=geometric mean; lower bar=lower 95% confidence limit
Source: Form 03, page 2, phases 02 and 03.

3.3 Mat Study Results

As discussed in Section 3.1, mat data in the 65-unit datset were difficult to interpret due to the presence of tenant mats at Phase 02, the removal of program mats between phases, and the addition and removal of tenant mats between phases. Therefore, the mat study portion of this report focuses on the smaller dataset of 23 units. For these 23 units, bare floors were sampled at all inside-unit locations in both Phases 02 and 03, and carpets were present only at outside-door locations in "program mat," "tenant mat," and "gain mat" units. These restrictions simplified the comparisons of data between different sample locations and between phases. Dust lead loading results for this 23-unit dataset are summarized in Table 3.

Table 3. Phase 02 and Phase 03 Dust Lead Loadings for Mat Study Dataset (23 units)

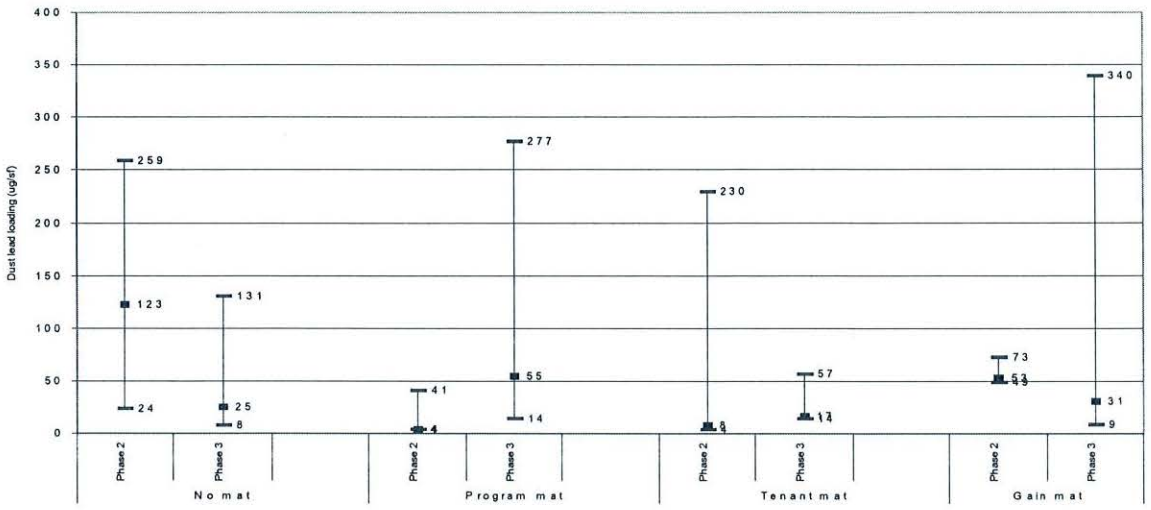
Study Category	Dust Lead Loadings (µg/ft²)[a]					
	Outside Door		Inside Door		Inside Room	
	Phase 02	Phase 03	Phase 02	Phase 03	Phase 02	Phase 03
"No mat" units (6 units):						
Minimum	*24*	*8*	*15*	*8*	*10*	*7*
Median	**123**	**25**	**68**	**31**	**53**	**16**
Maximum	259	131	554	45	522	28
"Program mat" units (7 units):	(carpet)	(carpet)				
Minimum	*4*	*14*	*47*	*4*	*25*	*4*
Median	**4**	**55**	**235**	**17**	**99**	**10**
Maximum	41	277	6,707	29	386	46
"Tenant mat" units (6 units):	(carpet)	(carpet)				
Minimum	*4*	*14*	*8*	*4*	*6*	*4*
Median	**8**	**17**	**31**	**10**	**16**	**7**
Maximum	230	57	328	38	129	20
"Gain mat" units (4 units):		(carpet)				
Minimum	*49*	*9*	*4*	*4*	*6*	*4*
Median	**53**	**31**	**50**	**17**	**24**	**9**
Maximum	73	340	59	90	37	17

[a]In "program mat" and "tenant mat" units, Phase 02 and Phase 03 sample results for the outside door sample location were from carpeted floors (i.e., mats). Phase 03 outside door sample results for "gain mat" units were carpeted floors. All other results were bare floors.

3.3.1 Outside Door Mat Study Results

Outside door mat study results for Phases 02 and 03 are summarized in Table 3 and Figure 3 and are discussed below.

Figure 3: Outside Door Mat Study Results for Phases 02 and 03



Note: Upper bar=maximum dust lead loading; box=median dust lead loading; lower bar=minimum dust lead loading.
Source: Form 03, page 2, phases 02 and 03

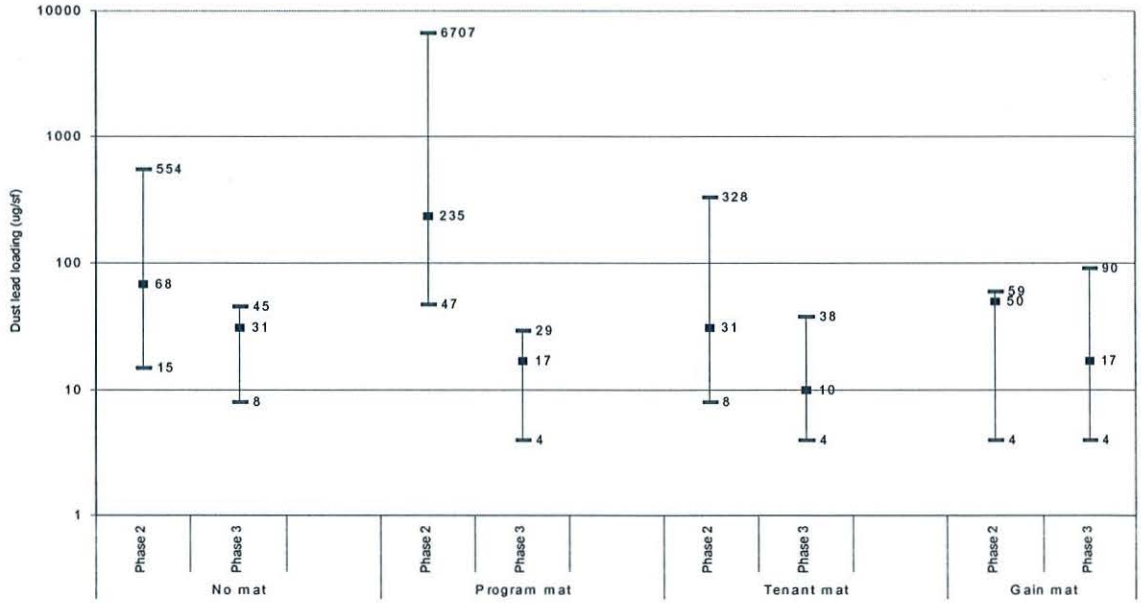
Phase 02. Not surprisingly, median dust lead loadings for bare floors in the "no mat" and "gain mat" units were greater than carpeted floor medians in the "program mat" and "tenant mat" units, where mats had just been placed. Although the length of time that tenant mats had been in place prior to sampling is not known, carpeted floor results for "tenant mat" units were similar to those for "program mats" and both were quite low (medians of 4 and 8 $\mu g/ft^2$, respectively). Several factors could account for these low "tenant mat" results, including the fact that, as discussed in Section 2.6, several "tenant mat" units had their tenant mats removed and replaced with program mats, which were then sampled. Thus, the low "tenant mat" results could be due in part to sampling new program mats, rather than tenant mats. Alternatively, tenant mats may have been recently placed prior to the Phase 02 visit and hadn't had time to get dirty, or they could have been recently cleaned.

Phase 03. For "no mat" units, median outside-door dust lead loadings decreased considerably from Phase 02 to Phase 3, likely due to the removal of lead sources when the units were treated. Between Phases 02 and 03 it was expected that, unless periodically cleaned, doorway mats in "program mat" and "tenant mat" units would become more dust-laden with time, yielding higher results at Phase 03 than at Phase 02. Limited interview data available at Phase 03 indicated that mats were periodically cleaned in some units.[2] Phase 03 median dust lead loadings for carpeted floors in "program mat" and "tenant mat" units were higher than those in Phase 02.

3.3.2 Inside Door Mat Study Results

Inside-door mat study results for Phases 02 and 03 are summarized in Table 3 and Figure 4 and are discussed below.

Figure 4: Inside-Door Mat Study Results for Phases 02 and 03 (Logarithmic Scale)



[2] Of 25 respondents to the Phase 03 interview (Form 07), 10 stated that the welcome mat had been cleaned one to more than six times during the past year; therefore, cleaning habits may have influenced Phase 03 results for several units.

Phase 2. Phase 02 inside-door dust lead loadings in "no mat" units and "gain mat" units were expected to be similar to those in "program mat" units, since program mats had just been put in place outside the door. In actuality, however, the "program mat" median of 235 $\mu g/ft^2$ was much higher than medians for either the "no mat" (68 $\mu g/ft^2$) or the "gain mat" (50 $\mu g/ft^2$) categories. This finding may indicate that, although units were randomly assigned to receive or not receive a program mat, "program mat" homes may have started out in worse condition. Since neither pre-intervention nor clearance data are available for all mat study units, baseline condition of units cannot be further investigated.

For tenant mat units, if mats were in place for a lengthy period prior to Phase 02 sampling, Phase 03 dust lead loadings were expected to be lower than those for units in other categories. The median dust lead loading for tenant mat units (31 $\mu g/ft^2$) was indeed lower than those of other three categories, possibly due to the tenant mat being in place longer.

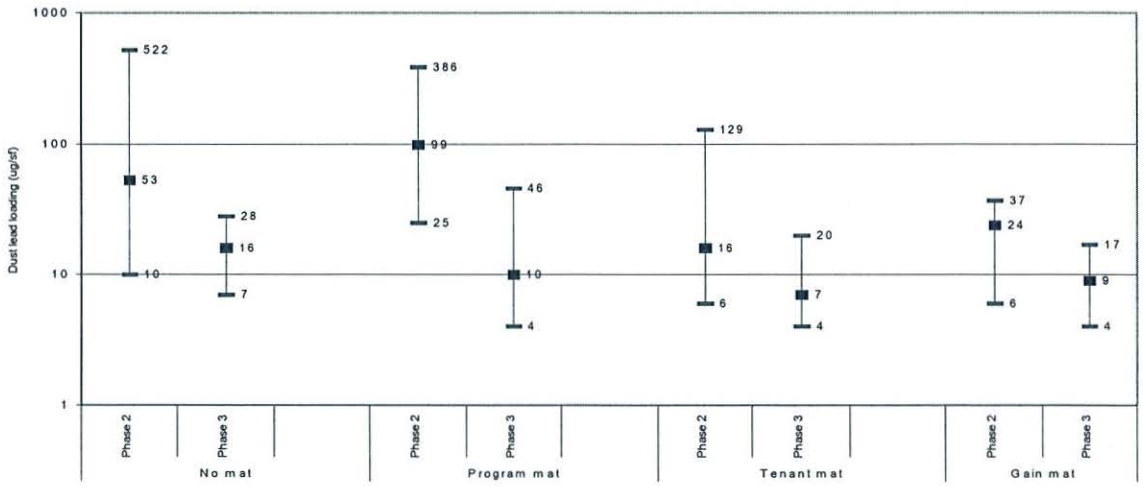
Phase 03. Regardless of study category, dust lead loadings inside the door decreased from Phase 02 to Phase 03, with "program mat" units appearing to have a greater reduction than units in other categories.

Because the mats were expected to help prevent lead-contaminated dust from being tracked inside the home, Phase 03 inside-door dust lead loadings in "program mat" and "tenant mat" units were expected to be lower than those in "no mat" units. Phase 03 dust lead loadings in "gain mat" units also could be expected to be lower than those in "no mat" units, depending on when mats were placed in the "gain mat" units. The median loading in "no mat" units (31 $\mu g/ft^2$) was indeed higher than the median loadings in the "program mat" (17 $\mu g/ft^2$), "tenant mat" (10 $\mu g/ft^2$) or "gain mat" (17 $\mu g/ft^2$) units, indicating a possible "mat effect."

3.3.3 Inside Room Mat Study Results

Inside-room mat study results for Phases 02 and 03 are summarized in Table 3 and Figure 5 and are discussed below.

Figure 5: Inside Room Mat Study Results for Phases 02 and 03 (Logarithmic Scale)



Phase 02. Phase 02 results inside the room were similar to those at the inside-door location. Phase 02 inside-room dust lead loadings in "no mat" units and "gain mat" units were expected to be similar to those in "program mat" units; however, the "program mat" median (99 $\mu g/ft^2$) was higher than medians for either the "no mat" (53 $\mu g/ft^2$) or the "gain mat" (24 $\mu g/ft^2$) categories. Although units were randomly assigned to receive or not receive a program mat, "program mat" homes may have started out in worse condition; however, insufficient data are available to further evaluate baseline unit conditions. As was seen at the inside-door location, "tenant mat" units had the lowest inside-room median dust lead loadings of the four categories, perhaps because tenant mats may have been in place for a lengthy period prior to Phase 02 sampling.

Phase 03. Similar to inside-door results, inside-room dust lead loadings decreased from Phase 02 to Phase 03, regardless of unit category. "Program mat" units appeared to experience a greater reduction from Phase 02 to Phase 03 than did units in other categories.

Because the mats were expected to help prevent lead-contaminated dust from being tracked inside the home, Phase 03 inside-room dust lead loadings in "program mat," "tenant mat," and possibly in "gain mat" units were expected to be lower than those in "no mat" units. This "mat effect," however, was more difficult to discern when reviewing the inside-room results. The median Phase 03 inside-room loading in "no mat" units (16 $\mu g/ft^2$) was higher than those in the "program mat" (10 $\mu g/ft^2$), "tenant mat" (7 $\mu g/ft^2$) or "gain mat" (9 $\mu g/ft^2$) units.

4. SUMMARY AND DISCUSSION

4.1 Discussion of the 65-Unit Results

Study results for the 65 study units generally indicate that the LSC program was effective in treating homes: At Phase 03, none of the 65 units had inside-door results greater than 100 $\mu g/ft^2$, and only seven had inside-door results above 40 $\mu g/ft^2$; only five units had inside-room results above 100 $\mu g/ft^2$ and only nine above 40 $\mu g/ft^2$. 03 than they did at Phase 02.

Phase 02 floor dust lead loadings, however, were higher than expected, with geometric mean loadings often exceeding a clearance level of 100 $\mu g/ft^2$ even though clearance testing had been performed an average of 31 days before. These high Phase 02 results indicate that postponement of cleaning in common areas until after all units in the multifamily building were treated may lead to track-in problems. Even if post-treatment cleaning of units is not very thorough, however, results show that lead hazards may decrease over time because the lead hazard sources have been removed or are much less prevalent.

4.2 Discussion of Mat Study Results

The mat study showed widespread use of mats by tenants. Almost half of the 65 study units had tenant mats already present when the HES contractor first visited at Phase 02, and several more gained mats at Phase 03. The presence of tenant mats hindered the LSC program in its ability to disseminate program mats in a useful fashion.

The crucial expectation of the mat study was that at Phase 03, bare floor dust lead loadings inside the home of "program mat" units and "tenant mat" units would be less than those in

"no mat" units. Study data indicate that mats may have had a slight effect on dust lead loadings inside homes: at Phase 03, median floor dust lead loadings inside the door of "program mat" and "tenant mat" units were 17 $\mu g/ft^2$ and 10 $\mu g/ft^2$, respectively, while that in "no mat" units was 31 $\mu g/ft^2$. It should be noted that at Phase 02, inside-door dust lead loadings for "program mat" units were higher than those of "no mat" units, complicating data interpretation. It is difficult to determine whether the low loadings observed in mat units at Phase 03 are due to the presence of the mats or due to the differences between units in each category at Phase 02. However, study results of lower dust loadings in dwellings with mats may support the findings of a previous study in the Pacific Northwest by John W. Roberts, which suggested that walk-off mats reduce the level of tracked-in lead-contaminated dust and soil. It is not possible to draw firm conclusions due to the small dataset and the slight changes observed. While the results could indicate that mats have a "trapping effect," causing lower dust lead loadings inside the room, they may alternatively indicate that people who routinely use mats also keep their house cleaner than those who do not routinely use mats.

5. RECOMMENDATIONS

Although tenant mats are already in use in many Cambridge homes and provision of walk-off mats to treated dwelling may not have tremendous impacts on indoor lead loadings, they may stillhelp to prevent track-in, and they are inexpensive. LSC may therefore wish to continue distribution of mats. It should be noted that the Phase 03 median outside-door dust lead loading for the "program mat" units (55 $\mu g/ft^2$) was greater than 40 $\mu g/ft^2$, indicating that contaminated mats pose a potential exposure hazard. LSC may want to consider educating tenant concerning maintenance and periodic replacement of mats to prevent contaminated mats from posing exposure hazards, and educating tenants and owners about the importance of general routine cleaning of dwelling units and common areas. Cleaning of common hallways at clearance should possibly be considered as part of all lead hazard reduction projects, even if interventions are not done in these common areas. Track-in hazards must also be considered during interventions in multifamily buildings, particularly for units having front doors that open directly onto porches.

For a variety of reasons, this study proved to be more difficult to implement than expected. Future studies of the impact of walk-off mats on indoor dust lead loadings should exert more control over the use of tenant mats (i.e., tenant mats should be removed). Frequent checks on the mat use patterns in all enrolled units should be performed, with investigators having more control over ensuring that program mats remain in their proper location. The presence of carpeting in the homes further complicated the successful implementation of the study; if feasible, future study data should focus on units with bare floors only. Finally, a larger group of enrolled units would allow more rigorous statistical testing of study hypotheses to be performed.

APPENDIX A

CAMBRIDGE WALK-OFF MAT STUDY PROTOCOLS AND BLANK FORMS

APPENDIX B
LABORATORY QUALITY CONTROL/QUALITY ASSURANCE RESULTS

Appendix B

Quality Control/Quality Assurance Results

B.1 Blank Results

Data are available for a total of 53 field blanks collected and analyzed during Phases 02 and 03. The collection rate for field blanks, approximately one for every two dwellings, is in agreement with study protocols, which called for one field blank to be submitted per day of sampling. All field blank results were less than the detection limit of 5 µg/sample.

B.2 QC Spike Results

QC spike results are summarized in Table B-1. Data are available for 11 spikes collected and analyzed during Phases 02 and 03. The submittal rate for spikes, approximately one for every 12 dwellings, is in agreement with the study protocols. Within one exception, all reported laboratory results were within the required 80 to 120 percent of the true spike value. One sample yielded a spike recovery of 121 percent, which was not considered a serious problem and was not further investigated.

Table B-1: QC Spike Sample Laboratory Recovery Results

Laboratory Result (µg/sample)	Spike Concentration (µg/sample)	Percent Recovery (%)
262	216	121
187	180	104
233	222	105
109	119	92
230	241	95
205	206	99
223	221	101
360	351	113
230	223	103
152	158	96
196	203	96